NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
February 1946 as
Restricted Bulletin L5K29a

STATIC-PRESSURE ERROR OF AN AIRSPEED INSTALLATION ON AN AIRPLANE IN HIGH-SPEED DIVES AND PULL-OUTS

By John A. Zalovcik and Clotaire Wood

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

L-43

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESTRICTED BULLETIN

STATIC-PRESSURE ERROR OF AN AIRSPEED INSTALLATION ON AN AIRPLANE IN HIGH-SPEED DIVES AND PULL-OUTS

By John A. Zalovcik and Clotaire Wood

SUMMARY

Tests were made in high-speed dives and pull-outs to determine, by combined radar-optical tracking equipment, the static-pressure error of an airspeed-head installation on a P-51B airplane. The installation included a pitot-static head mounted on a boom 95 percent chord ahead of the leading edge of the wing near the tip. The tests were made in dives at flight Mach numbers up to 0.75 and included pull-outs up to 4g normal acceleration.

The results indicated that the static-pressure error did not vary with Mach number by more than about 1 percent of the impact pressure over the range of conditions investigated.

INTRODUCTION

Flight data on the variation with Mach number of the static-pressure error of pitot-static-tube installations have generally been limited by the available testing techniques to speeds attainable in level flight. Inasmuch as the maximum speeds in level flight for most present-day airplanes do not exceed a Mach number of 0.6, the variation in static-pressure error with Mach number beyond this value has not been obtained hitherto in flight, although some information is available from wind-tunnel tests reported in reference 1.

For a recent high-speed investigation of a P-51B airplane, an airspeed calibration was required in dives and pull-outs up to a Mach number of 0.75. A method was therefore devised for obtaining such a calibration by use of radar-optical tracking equipment to establish the reference altitudes. The calibration obtained by this method was

supplemented by data obtained up to high speed in level flight by a method (described in reference 2), which makes use of a landmark or another airplane to provide the reference altitude.

The results of these calibrations are believed to be of general interest and are therefore reported herein.

SYMBOLS

p' static pressure indicated by airspeed installation

p free-stream static pressure or atmospheric pressure at altitude h

p_s NACA standard atmospheric pressure at altitude h (from reference 3)

H free-stream total pressure

q_c free-stream impact pressure $(H - p)$

M free-stream Mach number

C_L airplane lift coefficient

APPARATUS AND METHOD

Airplane equipment.- The airspeed-head installation of the P-51B airplane is shown in figure 1. A Kollsman type 651B airspeed head (fig. 2) was used and was mounted 95 percent chord ahead of the leading edge of the wing. The boom supporting the airspeed head was located 85 percent semispan from the plane of symmetry, at which station the wing section had a maximum thickness equal to 12 percent of the chord. Pressure leads from the static- and total-pressure elements of the airspeed head were connected to an NACA airspeed recorder to measure impact pressure; the static-pressure element was also connected to a recording altimeter.

The airplane was equipped with an NACA single component recording accelerometer, an NACA chronometric timer to synchronize all records, and a radio to communicate the timing signals to the ground equipment.

Ground equipment.- The tracking equipment used to establish the height of the airplane consisted of a combination of a radar unit for the determination of range and a phototheodolite for the determination of the elevation angle.

Test procedure.- The first step in the test procedure consisted in obtaining a survey in a climb at an indicated airspeed of 175 miles per hour over a range of altitude from about 15,000 to 26,000 feet in order to establish the relation of atmospheric pressure to actual altitude. In the survey, at intervals in altitude of approximately 1000 feet, simultaneous records were taken of static pressure, impact pressure, and normal acceleration in the airplane and of elevation angle and range of the airplane with the tracking unit. The airplane was then dived to a flight Mach number of 0.75 and pulled out with 2g normal acceleration within the range of altitude surveyed; continuous and simultaneous records of static pressure, impact pressure, normal acceleration, range, and elevation angle were made during these maneuvers. A second dive was made over the same range of altitude and Mach number but with a pull-out at a normal acceleration of 4g. After the second dive and pull-out the survey in climb was repeated and was followed by a survey in a descent at the same speed and over the same range of altitude.

The results of the surveys of atmospheric pressure are shown in figure 3 in which the difference between atmospheric pressure p and standard atmospheric pressure p_s is plotted against altitude h. The static pressures obtained in the climbs and during the descent were corrected to atmospheric pressure by use of the static-pressure error of the airspeed installation as determined from a low-speed calibration. This calibration was made over a range of Mach number from 0.24 to 0.43 by a method (described in reference 2) in which level-flight runs are made past a landmark or a reference airplane of known pressure altitude and a sensitive altimeter is used to measure the static pressure indicated by the airspeed installation.

The static-pressure error in the dive and pull-out was found by taking the difference between the static pressure measured at a given altitude in the dive and pull-out and the atmospheric pressure determined from the pressure surveys at the same altitude. Measurements of

static pressure, impact pressure, and normal acceleration were used to evaluate the Mach number and lift coefficient corresponding to the determined static-pressure error.

A ground check of the lag of the airspeed installation indicated that the effect of lag on the measurements was negligible.

RESULTS AND DISCUSSION

The results of the airspeed calibration made at Mach numbers of 0.24 to 0.43 in level-flight runs past a landmark and also past a reference airplane are presented in figure 4 as a plot of static-pressure error $\frac{p' - p}{q_c}$ against airplane lift coefficient C_L. The flight Mach numbers corresponding to the airplane lift coefficients are plotted above the curve for static-pressure error. The static-pressure error was constant over the range of the test conditions and was 1.8 percent of the impact pressure.

The static-pressure error determined in the two high-speed dives and pull-outs by means of the radar-optical tracking equipment is plotted in figure 5 against airplane lift coefficient for various ranges of Mach number and in figure 6 against Mach number for various ranges of airplane lift coefficient. The results of the level-flight calibration are also included in figures 5 and 6. At a lift coefficient of about 0.1, the static-pressure error showed no variation with Mach number within the experimental accuracy. At higher lift coefficients the static-pressure error showed a tendency to increase slightly with increasing Mach numbers; the increase was of the order of 1 percent of the impact pressure over the range of Mach number tested. These results are in agreement with those obtained from the wind-tunnel tests reported in reference 1, which indicated that for a static-pressure tube located 55 percent chord or more ahead of an airplane wing the variation of static-pressure error with Mach number was no more than about 1 percent of the impact pressure, at least for Mach numbers from 0.4 to 0.8 and for wing thicknesses up to 15 percent chord.

CONCLUSIONS

The calibration of an airspeed installation with the airspeed head mounted 95 percent chord ahead of the P-51B airplane wing near the tip indicated that the static-pressure error did not vary with Mach number by more than about 1 percent of the impact pressure up to the highest Mach number (0.75) covered in the tests.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. Lindsey, W. F.: Effect of Mach Number on Position Error as Applied to a Pitot-Static Tube Located 0.55 Chord Ahead of an Airplane Wing. NACA CB No. L4E29, 1944.

2. Thompson, F. L., and Zalovcik, John A.: Airspeed Measurements in Flight at High Speeds. NACA ARR, Oct. 1942.

3. Brombacher, W. G.: Altitude-Pressure Tables Based on the United States Standard Atmosphere. NACA Rep. No. 538, 1935.

Figure 1.- Airspeed head mounted on boom ahead of wing of P-51B airplane.

Figure 2.- Kollsman type No. 651B airspeed head.

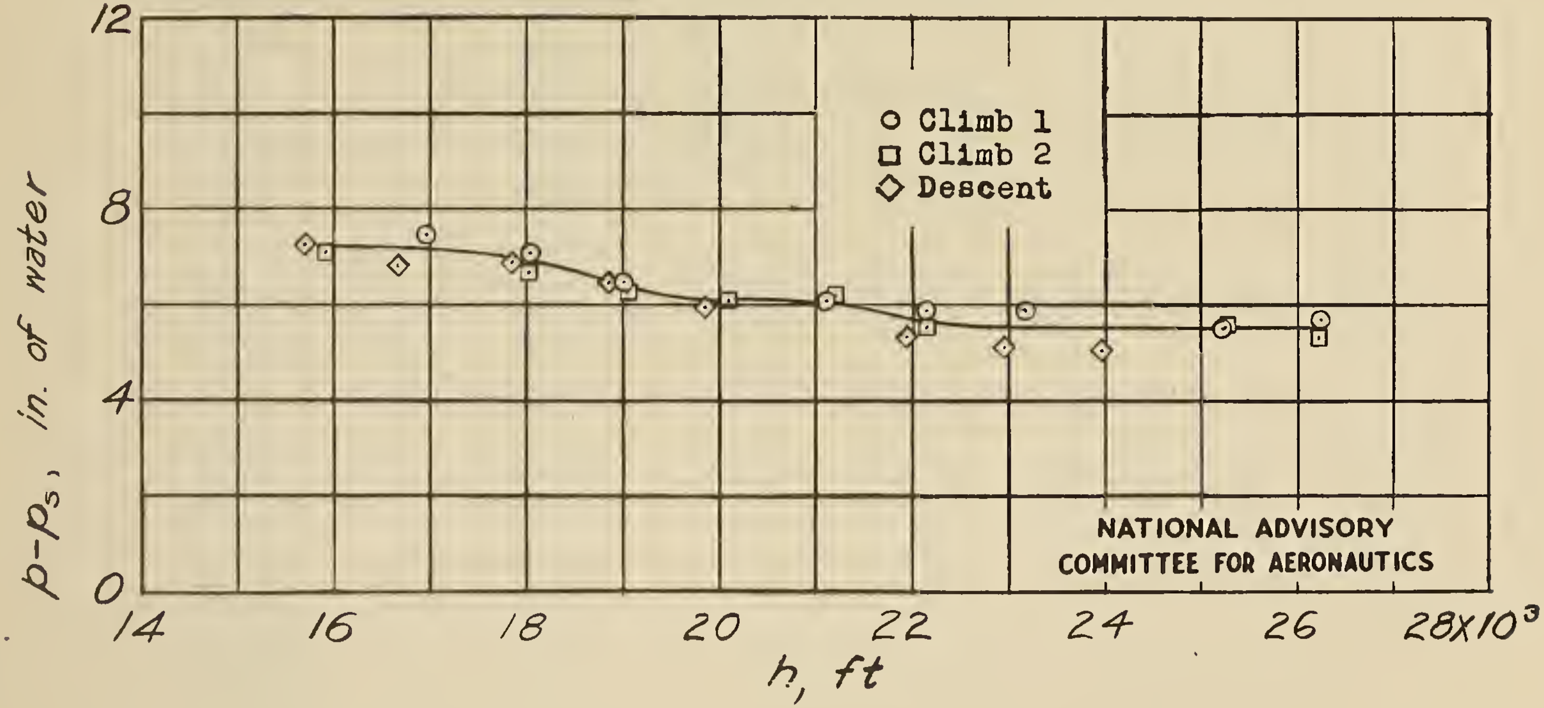


Figure 3.- Variation with altitude of the difference between atmospheric pressure and standard atmospheric pressure as determined from surveys.

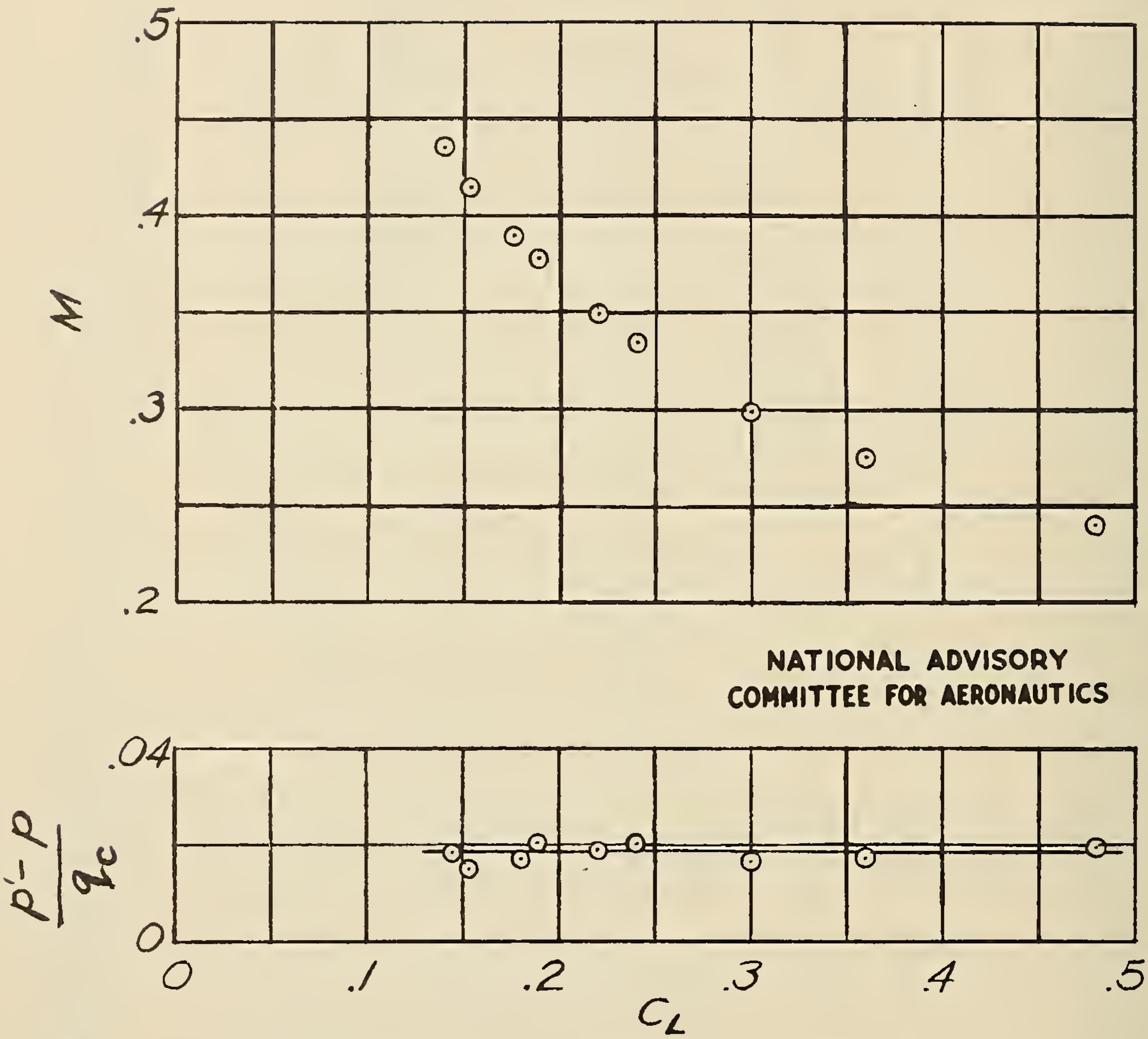


Figure 4.- Variation of static-pressure error with lift coefficient determined in level flight. Mach number corresponding to each value of lift coefficient also shown.

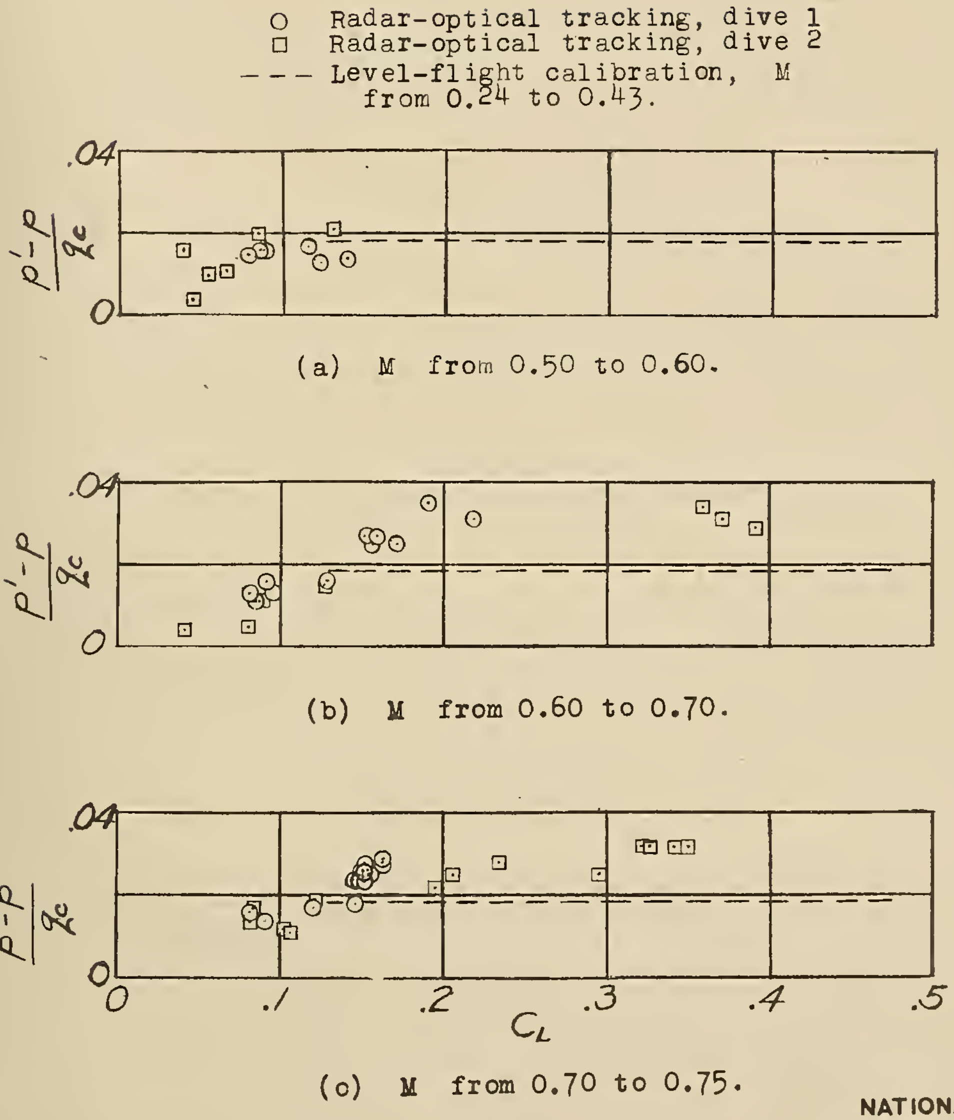
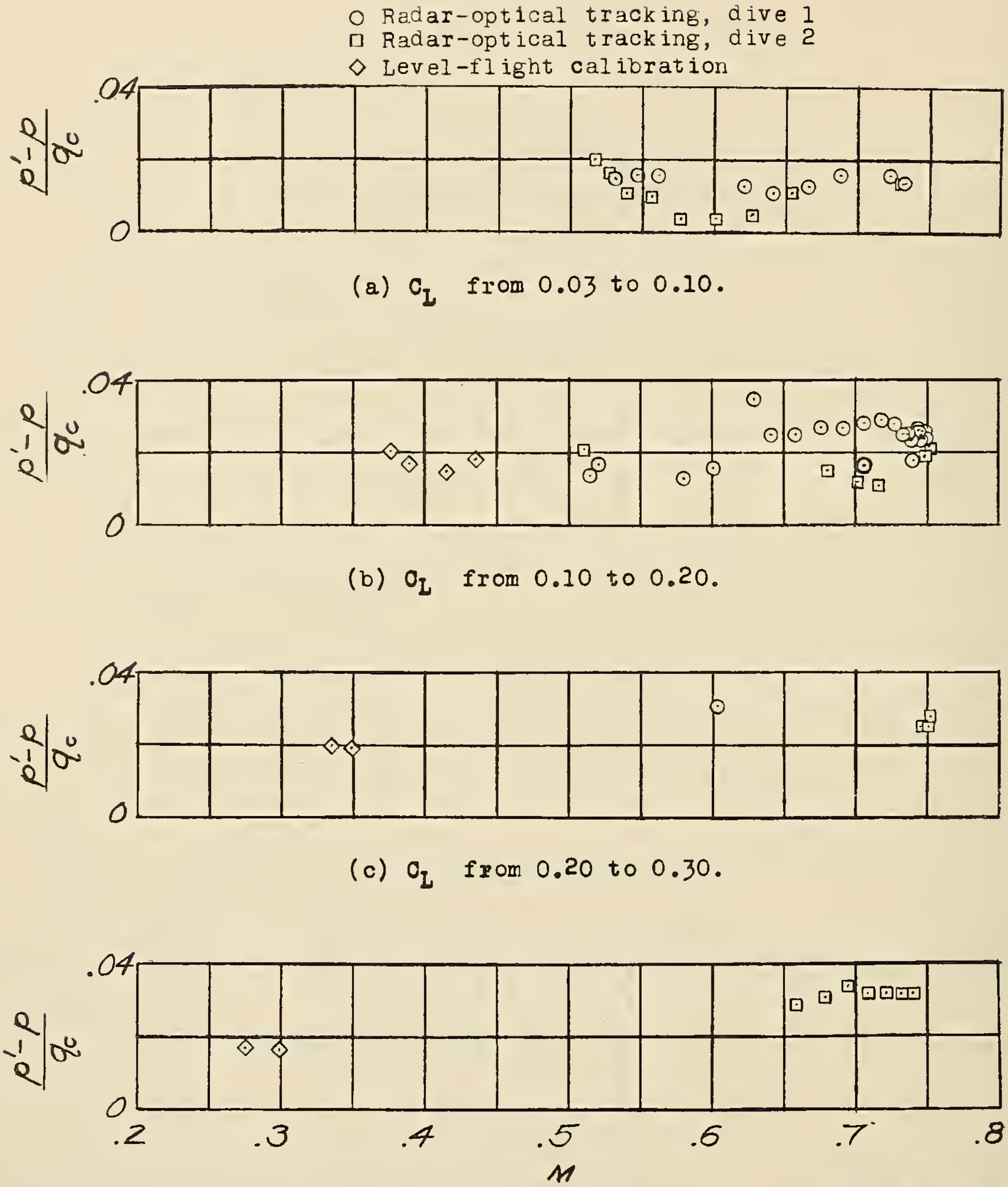


Figure 5.- Variation of static-pressure error with airplane lift coefficient for several ranges of Mach number.



(a) C_L from 0.03 to 0.10.

(b) C_L from 0.10 to 0.20.

(c) C_L from 0.20 to 0.30.

(d) C_L from 0.30 to 0.40.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Figure 6.- Variation of static-pressure error with Mach number for several ranges of airplane lift coefficient.